Institutional Effectiveness
2024-2025

Program: Physics BS
College and Department: College of Arts & Sciences, Physics
Contact: Stephen Robinson
Mission:

The TTU Department of Physics will promote the learning of physics and astronomy through effective teaching, research, and public service. Such learning opportunities are provided to students of all disciplines, in support of the mission of the University.

The department addresses this mission through various programs:

- a major program of study, with two options, leading to a B.S. in Physics
- programs of study leading to minors in Physics and Astronomy
- a service program that provides courses in physics and astronomy that are requirements for other degree programs or are used by students to fulfill general education science requirements.

Attach Curriculum Map (Educational Programs Only):
Attached Files: See Appendix 1

Learning Outcome 1 - Student Learning in Introductory Courses

Define Outcome:
Students completing calculus-based and algebra-based introductory physics courses will demonstrate increased understanding of foundational concepts in mechanics.

Assessment Methods:
Understanding of basic mechanics concepts will be measured using the nationally recognized Force Concept Inventory, a standard diagnostic test used at many institutions nationwide. It will be administered to all students at the beginning of both PHYS 2010 and PHYS 2110 courses, and then again after the relevant material has been covered. The normalized gain score will be used to judge improvement in understanding and is a measure of the actual improvement in performance after instruction versus the maximum possible improvement.

Criteria for Success (Thresholds for Assessment Methods):
For many years the targeted goal was a gain of 40%, but with recent improved performance, the target has now been raised to 45%. Currently, the minimum acceptable performance for any particular class section is a 30% gain, and any gain greater than 50% is regarded as exemplary.

Link to 'Tech Tomorrow' Strategic Plan:
1.B General Education Curriculum,1.D High Impact Practices

Results and Analysis:
The table below shows how sections of the targeted courses performed this year, in terms of the thresholds defined for this outcome. The attached chart shows a rolling 5-semester average for the performance of the two courses since 2015.

Course	Total sections	Below minimum (<30%)	Acceptable (30% - 44%)	Attained target (45% - 50%)	Exemplary (>50%)
PHYS 2010	7	4	1	2	0
PHYS 2110	10	7	3	0	0

Three years ago, a consideration of the historical trends shown in the graph for both PHYS 2010 and PHYS 2110 prompted the raising of the target for this outcome to a 45%

gain. However, it is evident that recently there has been a general downward trend in the 5-semester averages, which has only been exacerbated by this year's results. Indeed, this year's results for both courses were very disappointing, with only two of seventeen total sections attaining the target and only a further four being acceptable. In considering the declines that were emerging from the data, the faculty initially ascribed them to a combination of factors. Primary among these were decreased instructional time, decreased emphasis on conceptual understanding, and new faculty taking over these courses. While these may still be influencing factors, a previously disregarded factor has emerged – that of students not taking the test 'seriously'.

Prior to the COVID-10 pandemic this diagnostic test was given in a 'paper and pencil' format during a regular class session, with the instructor present. It should take a conscientious student about 20 to 30 minutes to complete this test, and that was generally the case for these in-class implementations. However, during the pandemic we switched to giving the test online and outside of class through the LASSO site (lassoeducation.org) and have continued this practice until now. As well as scoring the test, the LASSO site also records the time each student spends in completing it. Recently our local faculty coordinator examined this data, and it became apparent that many students were not spending more than a few minutes completing the test. Since it is generally accepted practice that any 'rewards' for completing such diagnostic tests should be based on completion and not 'correctness', this time-on-test data suggests that many of our students are not taking the test 'seriously'. Thus, the gain scores derived from this online implementation may not currently reflect the true extent of student learning.

Attached Files: See Appendix 2

Use of Results to Improve Outcomes:

Following our analysis of the time-on-test data, for the 2025/26 academic year we will revert to administering this diagnostic test as a paper and pencil test in all 'on-ground' sections of PHYS 2010 and PHYS 2110 to see if gain scores improve as a result. We are still considering how to address this issue with the online section of PHYS 2110.

Learning Outcome 2 - Learning of Physics Majors

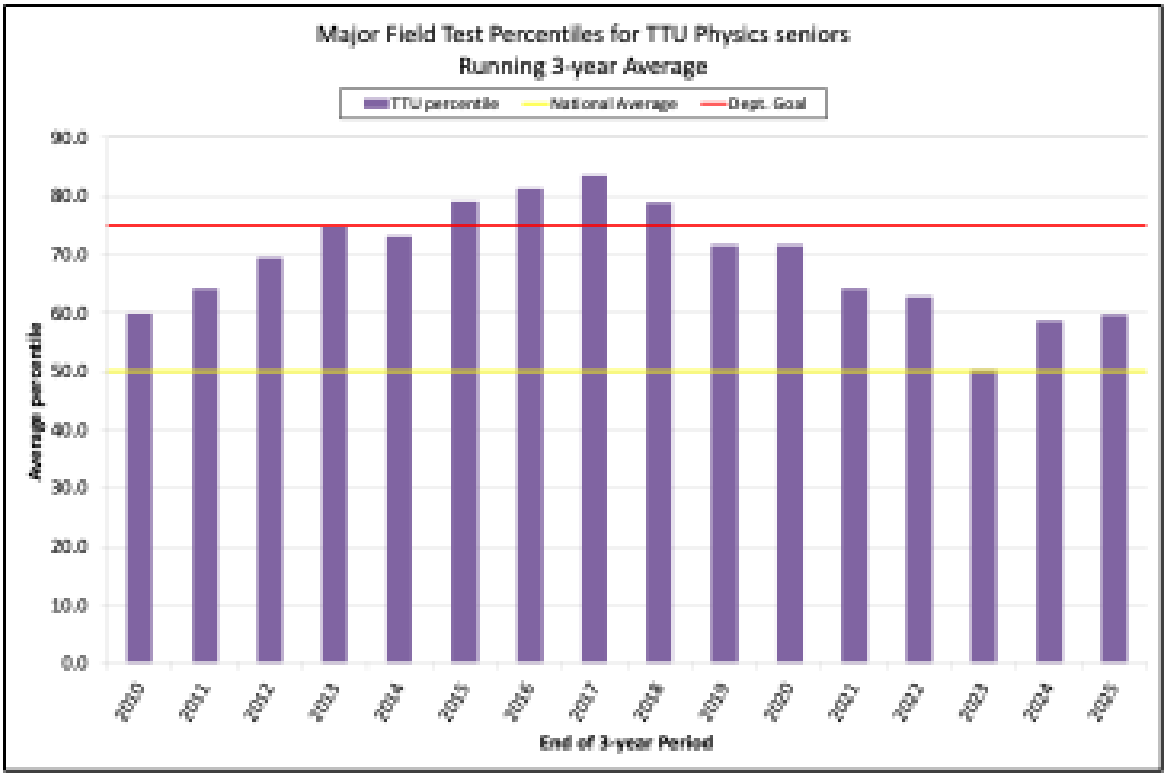
Define Outcome:
Students graduating in physics will demonstrate an understanding of the basic principles and foundations of physics.

Assessment Methods:
The ETS Major Field Test in Physics is a 70-item multiple-choice test that covers: Classical Mechanics and Relativity; Electromagnetism; Optics and Wave, Thermodynamics and Statistical Mechanics; Quantum Mechanics and Atomic Physics; and other Special Topics. All physics graduates will take the ETS Major Field Test in Physics during their final semester at TTU. Due to a low number of students, only two sub-scores are provided with the Exit exam results.

Criteria for Success (Thresholds for Assessment Methods):
The aspirational target is that graduating seniors will score, on average, at or above the 75th percentile on the ETS Major Feld Test in Physics, both on their overall score, and also on the two reported sub-scores. The threshold of acceptability is to have an average at or above the 50th percentile, thus maintaining a claim that TTU physics graduates are 'above average'.

Link to 'Tech Tomorrow' Strategic Plan:
4.B Programs, Certificates, and Training

Results and Analysis:
The three physics majors who took the Major Field Test this year scored, on average, at the 65^{th} percentile, with one surpassing the 75^{th} percentile target. Because of low numbers, it is difficult to base decisions on a single year’s scores. Therefore, we use a rolling three-year weighted average to examine trends. These results bring the three-year average up to the 60^{th} percentile, which is a slight improvement from last year, as shown on the graph. However, it will take another year for the poor results of the 2023 cohort to work through our three-year average.



The table below shows the averages of sub-scores on the two portions of the Major Field Test (Introductory and Advanced Physics) reported on a scale of 20-100, with the national average being approximately 50. The goal of an average at or above the 75th percentile corresponds to a sub-score of approximately 62 in each portion.

Year	Students tested	Sub-scores	
		Introductory Physics	Advanced Physics
2011/12	6	59	61
2012/13	5	58	74
2013/14	3	57	64
2014/15	3	71	68
2015/16	2	66	78
2016/17	3	60	65
2017/18	1	56	58
2018/19	5	59	63
2019/20	Due to Covid-19 pandemic, graduating seniors did not take test		
2020/21	2	46	53
2021/22	3	46	61
2022/23	5	42	54
2023/24	2	70	72
2024/25	3	52	63

These latest sub-scores seem to resume the general pattern, in that our majors seemed to perform more poorly on introductory topics than they do on advanced topics. To

address this, we will continue to focus on improving our majors' understanding of introductory topics using the strategies begun last year.

Use of Results to Improve Outcomes:
In discussing the long-term trend in sub-scores, last year the faculty identified and began to implement several strategies to better help physics majors develop a deeper understanding of introductory topics. We will continue with these in the coming year, many of which are being done in collaboration with the Tech Chapter of the Society of Physics Students (SPS):

- An emphasis on cohort building to encourage collaborative learning.
- Mentoring of freshmen and sophomores by upperclassmen.
- Closer tracking of physics majors in their introductory physics classes, to quickly identify when additional help is needed.
- Increasing the frequency of recitation/help/review sessions, which targeted physics majors will be encouraged to attend.
- Faculty reviewing and making connections to relevant introductory materials in more advanced classes.

Learning Outcome 3 - Physics Skills

Define Outcome:

Outcome: Students graduating in physics will demonstrate a range of competencies necessary to pursue a physics-related career. In particular, they will demonstrate the skills and techniques needed to:

- engage in authentic experimental investigation.
- communicate their work in a written format.
- communicate their work in an oral presentation format.
- use appropriate computational tools and techniques.
- engage in planning and carrying out basic or applied research.

Assessment Methods:

During their senior year, all physics majors take the following capstone set of courses:

- Advanced Experimental Physics (either PHYS 4710 (4 cr) or PHYS 4711 (2 cr))
- Computational Physics (PHYS 4130)
- Research Planning (PHYS 4730) and Research (PHYS 4740)

To be successful in this set of courses, students must apply and synthesize all of the skills addressed by this outcome, thus providing the opportunity to assess their degree of competency. In some cases, assessments of these skills may also be carried out in extracurricular contexts, such as summer research internships, student seminars, and conference presentations. The matrix below summarizes which skills may be assessed in which courses/context.

	Courses			Extracurricular (if applicable)	
Skills	**PHYS 4710/4711 (Adv. Lab.)**	**PHYS 4130 (Comp. Phys.)**	**PHYS 4730/4740 (Research)**	**Research Experience**	**Seminar/ Conference**
Experimental Investigation	X		X	X	
Written Communication	X	X	X	X	
Oral Communication	X	X	X		X
Computation	X	X	X	?	
Research	?		X	?	

X = Definite context for assessment

? = Possible context for assessment

The outcomes and rubrics used to assess these skills were finalized during this year and are attached. Based on how many outcomes are achieved and at what level course instructors, research supervisors, and other faculty (depending on the context) rate a student's performance on a particular skill as 'Exceeds Expectations (5)', 'Meets Expectations (4)',

'Developing-High (3)', 'Developing-Low (2)', or 'Insufficient Evidence (1)'. The final rating for a particular skill is then taken as the average of all the individual ratings. For graduating seniors an overall evaluation of the ensemble of skills is obtained from an average of the average ratings of the five individual skills.

Criteria for Success (Thresholds for Assessment Methods):
The aspirational target is that graduating seniors will be assessed as 'Meets Expectations' on each individual skill, and on the ensemble of skills. The minimum acceptable level is 'Developing-High', and any average rating of 'Exceeds Expectations' is regarded as exemplary.

Link to 'Tech Tomorrow' Strategic Plan:
1.D High Impact Practices,2.A Technology Infused Programs

Results and Analysis:
In preparation for the evaluation of graduating seniors, final versions of the outcomes and rubrics were agreed upon at the end of the year. The only substantive change was the consolidation of two separate sets of outcomes/rubrics for research skills into one. All these finalized rubrics were then applied to our three graduating seniors, giving the results shown in the table below.

Skill	Exceeds Expectations	Meets Expectations	Developing-High	Developing-Low	Insufficient evidence
Experimental Investigation	2	1			
Written Communication		3			
Oral Communication	1	2			
Computation	1	1	1		
Research			3		
Overall	1	1	1		

Most of the individual skill ratings met or exceeded the target and none fell below the minimum acceptable level. That no students met the target for research skills is a slight concern, but with such low numbers of graduates it will take several years of data accumulation to identify definite areas of excellence or deficiency. Overall, we can deem this outcome as having been met by two of the three members of this year's graduating class.

Use of Results to Improve Outcomes:
With outcomes and rubrics now finalized we will continue to apply them to our graduating seniors and examine the accumulated data to see if any areas of deficiency emerge.

Learning Outcome 4 - Career Preparation

Define Outcome:
Graduates of the TTU physics program will agree that the program gave them a well-rounded, scientifically and technologically grounded preparation, with strong analytical skills, such that they were well prepared for their next career step.

Assessment Methods:
Exit Interviews: While students who are getting ready to graduate from the program do not have the benefit of post-program experience, they do have a fresher recollection of their TTU experiences and so can provide valuable feedback on some elements of the program. In their exit interviews, students will be explicitly asked about how well prepared each student feels for their next career step, both overall and in terms of individual elements.

Alumni Surveys: Because of the low number of physics graduates, surveys are administered to department alumni on an approximate 5-year cycle. Among the questions asked are how effectively graduates felt the TTU physics program prepared them for their chosen career path.

Criteria for Success (Thresholds for Assessment Methods):
All graduating seniors and alumni will agree that the program prepared them well to continue on to graduate school in physics (or a closely related discipline) or to enter immediate employment, whichever is relevant to their particular situation.

Link to 'Tech Tomorrow' Strategic Plan:
1.A Experiential Learning,1.D High Impact Practices,4.B Programs, Certificates, and Training

Results and Analysis:
Exit Interview: Exit Interviews were conducted with three graduating seniors this year. Two were intending to go to graduate school in physics and deemed their preparation for this to be good. However, the student who was intending to enter immediate employment felt the department could have done more to help in terms of career exploration and guidance. We note that this concern has also been expressed occasionally in the past by some graduating students not intending to pursue graduate studies.

Alumni Survey: A survey was conducted in Fall 2023 and, relevant to this SLO, alumni continue to report being highly satisfied with the program and the overall level of preparation they receive for their future careers.

With these results it seems this learning objective continues to be met for those intending to go to graduate school. However, it seems that we need to do more to in terms of career exploration and guidance for those not interested in graduate study.

Use of Results to Improve Outcomes:
Results indicate that, for students intending to pursue graduate studies, no action is necessary. However, it is apparent that we need to pay more attention to developing and assisting in career awareness for those intending to seek immediate employment. We note that coincidentally 'Career Readiness' is one strand of the university's new Quality Enhancement Plan (QEP) and so we will address this outcome through a combination of university-wide resources developed in the context of the QEP and a joint effort with our SPS chapter to better emphasize the wide variety of career choices that do not include graduate study.

Therefore, starting in Fall 2025 we will incorporate the Gold Career Readiness certificate program into our freshman seminar course, PHYS 1137 (Frontiers of Physics). We will also consider how we can incorporate participation in the Purple Career Readiness program for our juniors/seniors.

In addition, with our SPS chapter, we will implement a panel session to which we will invite physics graduates (if possible, including some of our own) who have followed career paths that did not involve graduate study.

Program Goal 1 - Number of Physics Majors

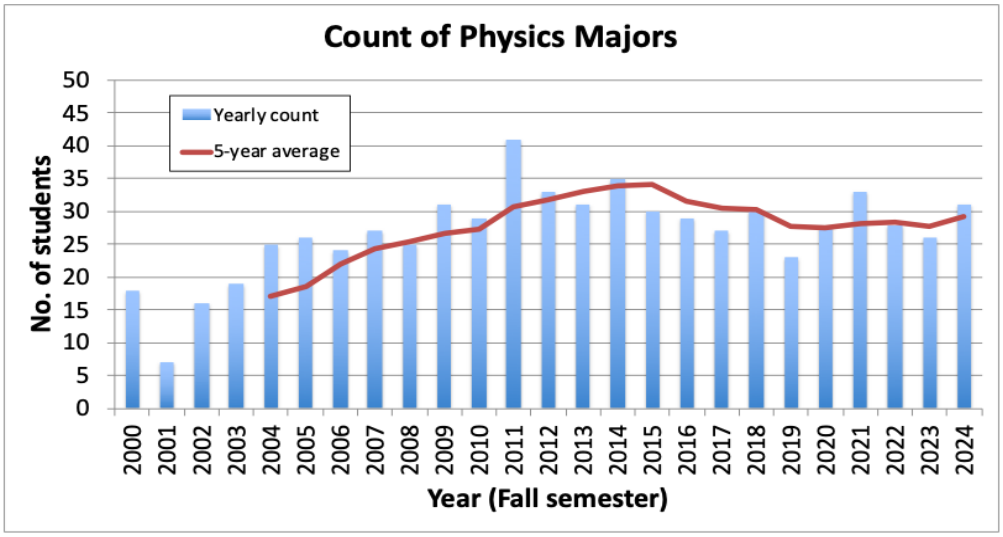
Define Outcome:
The Department will recruit and retain sufficient majors for a thriving educational program.

Assessment Methods:
At the beginning of each fall semester a count is made of the number of the total number of enrolled students who have Physics declared as a major. Because of the small numbers involved, trends are tracked using an average of the current year plus the previous four years. The department chair maintains a spreadsheet that tracks these numbers.

Criteria for Success (Thresholds for Assessment Methods):
The current target is that this average will increase by at least one per year. Having sustained an average of at least 30 majors for several years, the current minimum acceptable threshold is that the average number of majors should not drop below 30.

Link to 'Tech Tomorrow' Strategic Plan:
4.B Programs, Certificates, and Training

Results and Analysis:
At the start of this year the number of students declaring a physics major was 31, an increase of 5 majors over last year. This increased the 5-year average by 1.6 students to 29.2, which meets our current target for growth, and moves us closer to the minimum threshold of 30. This increase is encouraging and hopefully reflects the retention efforts implemented this year, based on cohort building and mentoring.



Use of Results to Improve Outcomes:
Despite the improvement this year, the 5-year average still hovers around the minimum threshold. While we seem to be having some success with retention, we still need to improve recruitment. Speaking with prospective students at recruitment events we noted a frequent interest in both astrophysics and the application of computers in physics. As part of a department 'retreat' to discuss program reorganization it was agreed that we had the expertise in the department (and in partnership with the Department of Computer Science) to offer programs in these areas.

Therefore, during the past year we designed two new concentrations, and restructured our existing ones, to hopefully make them more attractive to a broader range of potential recruits. To this end, starting in Fall 2025 we will offer four different concentrations within the Physics B.S. program:

- *Pure Physics*
- *Applied Physics*
- *Astrophysics*
- *Computational Physics*

In the coming year we will engage in a campaign to publicize these concentrations and hopefully improve recruitment as a result. Evidently, we will have to wait at least two years to see whether this has an effect, but we note that some of our current majors have already opted to switch to the new concentrations.

Program Goal 2 - Improving Instruction

Define Outcome:
Ensure the use of effective and innovative pedagogical methods within the classroom.

Assessment Methods:
In their annual effort reports, all faculty will be expected to report on changes/innovation in instruction, reflecting on their utility with regard to student learning and attitudes. Changes that result in improved student performance will be shared with the department as a whole.

Criteria for Success (Thresholds for Assessment Methods):
As a minimum, every faculty member is expected to report on at least one such strategy per year, together with an assessment of its effectiveness.

Link to 'Tech Tomorrow' Strategic Plan:
1.A Experiential Learning,1.B General Education Curriculum,1.D High Impact Practices,4.B Programs, Certificates, and Training

Results and Analysis:
All faculty members reported on implementing new strategies in at least one of their courses this year, though not all reported an assessment of their effectiveness beyond general impressions. Thus, this goal was mostly, but not completely, achieved.

One of the recommendations from our program review in spring 2024 was to consider revising our introductory calculus-based courses in terms of both content and assessment. Thus, almost all the changes/innovations tested and reported on this year addressed this course sequence. Four faculty members continued their development of completely online versions of these courses (both lecture and lab), reporting on innovations in both implementation and assessment. Four different faculty members reported on changes in the in-person sections of these courses. Among the different approaches reported on were:

- Giving students definite learning outcomes for the course and identifying test items and assignments with specific targeted learning outcomes.
- Allowing students more than one attempt to demonstrate their mastery of learning outcomes.
- Basing grades on several short lower-stakes assessments, rather than a small number of high-stakes exams.
- Efforts to incorporate both mini-lectures and active learning in in-person classes.

- The use of Gradescope© software to facilitate more efficient and uniform grading of assignments.

At the time of reporting, grade distributions for the Spring 2025 semester were not available, but for the Fall 2024 semester these changes in approach were likely a factor in a ~10% drop in DFW rates for these courses over the previous fall.

Use of Results to Improve Outcomes:

The apparent success of the innovative approaches to both the online and in-person sections of these courses have already been shared with the whole department. Of particular interest was the potential use of Gradescope© as an assessment tool in both lecture and lab, and several faculty members have already committed to testing it in both these contexts during the coming academic year and will report on its utility.

Program Goal 3 - Undergraduate Research Experience

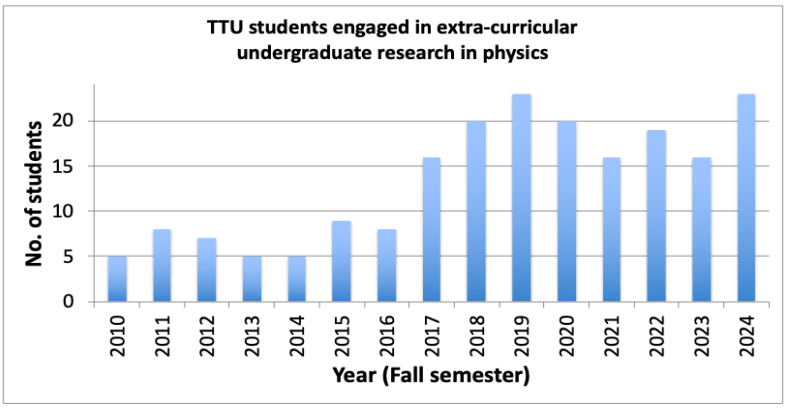
Define Outcome:
All physics majors will have the opportunity to gain experience in basic or applied research.

Assessment Methods:
The department chair will keep a record of student participation in the research of department faculty members and in specialized programs for undergraduates at other institutions (e.g. REUs and SULIs). (Note: Since almost all such experiences must necessarily take place during the summer it is impossible to ensure that all students will take advantage of such opportunities. However, the department will encourage such participation as actively as possible.)

Criteria for Success (Thresholds for Assessment Methods):
The targeted outcome is that all physics majors will have the opportunity to engage in such opportunities as many times as they wish during their TTU career. At a minimum, any interested student should engage in at least one such opportunity.

Link to 'Tech Tomorrow' Strategic Plan:
1.A Experiential Learning,1.D High Impact Practices,2.B Research, Scholar, Intellect, and Creativity

Results and Analysis:
During this year a total of twenty individual undergraduate students participated in research activities of various types with department faculty members and a further three in REU programs at other institutions. This is the highest number for several years and is, at least in part, due to our second-year tenure-track faculty member establishing a research program and involving students for the first time. All physics majors who desired such an experience were accommodated, thus achieving the target for this goal.



Use of Results to Improve Outcomes:

With this goal currently being achieved, we will maintain our current strategies of broadly publicizing research opportunities and requiring a commitment to undergraduate research in future tenure-track faculty searches.

Summative Evaluation:

- Recruitment of sufficient numbers of physics majors to maintain a thriving program. This has been addressed by the revision of our programs of study to hopefully make them more attractive to prospective students. We will mount a campaign to publicize these new programs and monitor interest and enrollment to determine if they are having the desired effect.
- Decline in diagnostic testing scores in PHYS 2010 and PHYS 2110. An analysis of online testing data revealed that many students are taking only a short amount of time to complete this assessment, suggesting they are not taking it seriously. In the coming year we will revert to an in-person implementation for in-person sections of these courses to see if scores improve.
- Declining overall Major Field Test scores for Physics majors, and the lower performance on the Introductory Physics sub-score. Including this year's graduating cohort in the three-year average gave a small improvement in the overall score, but the disparity between introductory and advanced physics re-emerged. However, the numbers are so small that will have to continue monitoring this data for a few more years to assess as to whether the measures we introduced last year are having an effect.
- Assessment of graduating seniors' physics skills. With outcomes and rubrics now finalized we anticipate having to accumulate data for at least two or three more years before any areas of deficiency can be identified.
- Career guidance and preparation for those not intending to pursue graduate study. Exit interviews with those graduating seniors seeking to enter immediate employment have revealed that we could do more to help them identify possible career paths and how to prepare for them. In parallel with the new university QEP, we will have students participate in career readiness certificate programs, as well as initiate a yearly panel session dedicated to this.

Assessment Plan Changes:

The only assessment plan change is for Learning Outcome 1, for which we will give the diagnostic test in person during a regular class meeting, rather than as an online asynchronous survey. In this way we hope to encourage students to take the assessment 'seriously' and so have the results be a truer measure of their learning.

List of Appendices:

Appendix 1: Curriculum Map
Appendix 2: Diagnostic Test Chart

Appendix 1: Curriculum Map

		Goals/Learning Outcomes					
Course	Title	Physics knowledge	Analytical skills	Laboratory skills	Communication skills	Computational skills	Research experience
PHYS 1137	Frontiers of Physics	X			x		
PHYS 2110	Calculus-based Physics I w/lab.	X	X	X			
PHYS 2120	Calculus-based Physics II w/lab	X	X	X			
PHYS 2420	Modern Physics	X	X		X	X	
PHYS 2920	Mathematical Physics	x	X		X	X	
PHYS 3610	Classical Mechanics	X	X		X	X	
PHYS 4610	Classical Elec. & Mag. I	X	X		X	X	
PHYS 4620	Classical Elec. & Mag. II	X	X		X	X	
PHYS 3120	Statistical Thermal Physics	X	X		X	X	
PHYS 3810	Quantum Mechanics I	X	X		X	X	
PHYS 3820	Quantum Mechanics II	X	X		X	X	
PHYS 4710/ PHYS 4711	Advanced Experimental Physics	X	X	X	X	X	
PHYS 4130	Computational Physics	x	X		X	X	
PHYS 4130	Research Planning	X	X	X	X	X	X
PHYS 4140	Research	X	X	X	X	X	X

Appendix 2: Diagnostic Test Chart